PROGRESS REPORTS

FROM

EXPERIMENT STATIONS

SEASON 1959-60

ADEN PROTECTORATE

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RESEARCH SECTION, EL KOD

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ADEN PROTECTORATE

RESEARCH SECTION, EL KOD

PROGRESS REPORT FOR THE SEASON 1959-60

BY

K. R. M. ANTHONY, J. E. A. OGBORN and J. H. PROCTOR

Planting dates	*Picking dates*	*Close season*
August-September	January-end May	End May-1st August

Introduction

General

The 1959-60 season marked the completion of the first five years of the station's existence as a separate section of the Department of Agriculture. Information obtained during this period now provides a factual background for the planning of a rotational farming system to replace the present haphazard method of cropping, which results in misuse of both land and water. It has been possible to make recommendations for cotton cultivation, water usage and pest control, which, if put into practice, will result in a substantial improvement in the standard of local cultivation. Unfortunately, there is a wide gap between what is technically desirable and practical and the cultivation practices of the average farmer. Although there has been some improvement in the standards of the better farmers those of the poorer have deteriorated and there is an urgent need for more intensive extension work.

Routine investigations of the performance of alternative types of cotton have been maintained, but it is emphasised that this does not imply any intention of changing the present commercial type.

Trials have been carried out on the mechanisation of the cotton sowing and cleaning operations and preliminary recommendations put forward, based on the use of a rigid tine cultivator.

It is suggested that a significantly lower incidence of Abyan root rot of cotton under heavy watering, compared with a light application, may be related to the distribution in depth of the early rooting system of the cotton plant. The effect of heavy watering was to reduce crop growth and yield.

A relationship has emerged between the incidence of *Diparopsis* and annual variation in the cotton acreage, and it is shown that the relation between moth flight and the cotton crop is a most important natural control. Control must be based on a strict close season and restriction of cotton sowing to August and September, whilst it is important to ensure the early watering of land cropped with cotton the previous year and to avoid a dry fallow immediately after cotton.

In a trial at Kod the insecticide Rogor 40 proved effective in the control of *Empoasca* and *Aphis*.

The logical expansion of the work of the station, particularly in the field of crops other than cotton and on Abyan root rot, is dependent on future availability of funds and staff. Proposals are still under discussion.

It was not possible to obtain a visit from a plant pathologist during 1959-60, but again we are indebted to Dr. W. J. Dowson for examining material sent to him at Cambridge. There remains the need for a man to do investigations on the spot.

Peaceful conditions prevailed throughout the Protectorate and security was better than at any other time within the last few years. As a precaution, guards are still stationed in the officers' compound.

Mr. D. F. Ruston, Director of the Empire Cotton Growing Corporation, and Mr. H. L. Manning, Director of the Cotton Research Station, Uganda, visited the station during the year. Amongst the numerous other visitors to the station were: Mr. D. Rhind, Secretary for Colonial Agricultural Research; the late Mr. H. Morrice, formerly Irrigation Adviser to the Secretary of State, and his successor, Mr. D. S. Ferguson; Mr. B. J. Surridge, Secretary of State Adviser on Co-operation; and Dr. E. M. Thain of the Tropical Products Institute.

Mr. K. R. M. Anthony attended the Cotton Spinner-Breeder Conference in Liverpool in July 1959 and Mr. J. H. Proctor the Seventh Commonwealth Entomological Conference in London in July 1960.

Weather

Meteorological data for the season are summarised in Table 1. Winter night temperatures were, for Aden, low.

TABLE 1

SUMMARY OF METEOROLOGICAL DATA

El Kod cropping season 1959-60

Month	*Temperature*		*Humidity*		*Sun-shine hours*	*Wind miles/hr.*	*Rain*		*Daily total radiation*[1] *cal/cm²*
	max.	*min.*	*a.m.*	*p.m.*			*in.*	*days.*	
August	93·2	77·2	82	58	8·7	5·70	—	—	524
September	94·1	76·3	88	64	9·2	3·99	1·50	1	521
October	91·9	71·6	89	67	9·9	4·09	—	—	524
November	87·1	67·8	84	62	10·0	4·89	Tr.	1	488
December	83·3	67·5	86	71	9·2	5·13	0·08	5	434
January	82·6	66·4	89	68	8·5	4·82	0·09	4	445
February	83·8	62·8	88	59	10·4	4·71	—	—	542
March	87·3	72·9	82	63	7·5	5·36	0·48	6	509
April	89·6	72·9	81	59	10·2	5·18	0·03	1	602
May	93·6	75·2	83	59	10·0	4·12	2·63	1	557

[1]Kipp solarimeter at R.A.F. Khormaksar.

A Baird & Tatlock Gunn-Bellani radiation integrator has been in operation at El Kod for the last 20 months. Calibrated against a Kipp solarimeter, the integrator has a remarkable degree of accuracy for so cheap an instrument and has undoubted merits for outstation work. Mean monthly radiation data from September 1958 to May 1960, calculated from the instrument at El Kod, gave a correlation coefficient of 0·869 with calculated R_c for these months.

Water Supply

The spring (seif) irrigation supplies in Abyan were below average in April, May and June 1959. Only 11·8 million cubic metres were received and were reported to have watered about 3,100 acres of land for crops other than cotton, mostly sorghum for fodder. This gives a nominal water duty of 94 cm.

The kharif flood during July, August and September was of average volume and easily distributed, 109·5 million cubic metres giving a total reported watered area of 32,400 acres. The effective areas of crops were reported to be 24,000 acres of cotton and 4,000 acres of other crops. Thus the average nominal application for the kharif was 82 cm, in contrast with the previous season's average of approximately 60 cm with a more restricted supply.

In Lahej a total supply of 17·8 million cubic metres was received during April, May and June and a further 203·5 million cubic metres were received during July, August and September. Transmission losses were estimated to be about 50 per cent. and, in addition, a large part of the September flow was lost to the sea. Nevertheless, a total of 12,000 acres of cotton and 8,700 acres of other crops was reported to be planted. This represented an average nominal application of 110 cm, even if the complete September flow be assumed to be lost through breakage to the sea, and is the first time that direct numerical evidence has been available to assess performance of the Lahej canalised basin irrigation system. It would appear that, though it is undoubtedly a better system of water control than the Abyan field-to-field system, the average nominal application in 1959 at least was higher. This probably indicates that the relative freedom which Lahej experiences from salinity troubles is due mainly to good natural drainage in the area at present under irrigation.

Studies of crop water consumption were continued: on land of high fertility at El Kod it was found that water consumption of cotton on a treatment receiving 30 cm of applied water was 55 cm stored water, and on a treatment receiving 15 cm application, 40 cm. The increased consumption of the crop in the higher water duty treatment occurred

in the period preceding full leaf cover; vegetative growth was greater and water strain occurred so that the crop did not yield to its full potential.

The Cotton Crop

From the point of view of total cotton production and prices the season was satisfactory. With regular small floods, easy to control, 24,000 acres were planted to cotton in Abyan. A particularly good crop was obtained in the southern part of Abyan, which owing to poor floods had remained fallow in 1958-59, and the average yield for the delta was 800 lb seed cotton per acre. Total production was 17,006 bales, bulking in grades 3 and 4. With careful picking the crop would normally bulk in grade 3.

In Lahej, 12,000 acres of cotton have yielded 12,522 bales, a record production for the area. In terms of percentage grade, Lahej was again slightly below Abyan and the crop has bulked in 4.

Approximately 6,500 acres of cotton were planted in the outside schemes, most of which are organised into Farmers' Co-operative Societies, and produced 3,864 bales. Of this total, 1,600 bales were obtained from the 1,800 acres bulking area at Yeramis, which averaged 1,000 lb seed cotton per acre. As a result of poor picking, the Yeramis crop, potentially grade 3, bulked in 4 and 5. With the exception of the small bulking area of Um Gibla (4) the remaining areas bulked in grades 5 and 6, dirty, mixed pickings being important contributory causes. In consequence of bad picking, power driven screens have been installed in the El Kod ginnery for the mechanical cleaning of dirty cotton prior to ginning. Two remedies immediately suggest themselves for the improvement of picking standards: purchase of seed cotton by grade and better supervision of cotton cultivation in the outside areas. The last can be put into practice now that good security conditions prevail. The first is only a problem of organisation.

Protectorate production thus totalled 33,392 bales, the highest so far attained. A summary of production in the last five years is given in Table 2.

TABLE 2

COTTON ACREAGE AND PRODUCTION

	ABYAN			LAHEJ			PROTECTORATE		
Season	*Acreage*	*Bales*	*Mean grade*	*Acreage*	*Bales*	*Mean grade*	*Acreage*	*Bales*	*Mean grade*
1955-56	18,000	15,776	3·9	7,000	10,368	3·5	30,000	30,700	3·9
1956-57	24,000	13,628	3·7	8,000	9,148	3·9	38,000	28,310	4·0
1957-58	25,000	14,595	3·5	13,500	10,829	3·7	43,000	28,752	3·7
1958-59	14,000	10,037	3·7	3,000	4,139	4·0	28,000	18,806	4·0
1959-60	24,000	17,006	3·6	12,000	12,522	4·1	42,500	33,392	3·9

The improvement in prices for long staple cottons has resulted in renewed interest in cotton amongst farmers in the smaller producing areas and, given good floods, there is likely to be an increased acreage planted to cotton next season. However, in the next five years production in any one year is unlikely to exceed 40,000 bales.

In Abyan, clean-up of the crop after harvest was probably the worst on record and in some areas unburnt cotton stalks were in evidence on 1st August.

Plant Breeding

BY

K. R. M. ANTHONY

Cotton Selection and Propagation

The replicated progeny row trial at El Kod comprised 52 progenies with bulked selections from BAR XL1 in a 7 × 8 rectangular lattice with three replications. Vegetation growth was very strong and yields high. Selections for yield were carried forward for further testing.

With improved security it has been found desirable to revert to the former propagation areas of Um Gibla and Yeramis and a nucleus bulking area at El Kod provided seed for the first commercial bulking area at Um Gibla. Seed from Um Gibla will be used to plant Yeramis next season and 1,800 acres at Yeramis have provided enough seed for sowing the whole of the Protectorate crop in 1960. K1 in these areas has averaged 1,000 lb seed cotton per acre and the cotton classifier has expressed a favourable opinion of its quality.

Independent bulking of seed by Lahej has not worked well and the State will also sow Yeramis seed in 1960-61.

Variety Trials

Two variety trials were laid down at Giar, but yields were severely reduced by extremely heavy shedding and no valid comparison could be made between strains and varieties under test.

Sample bales of Wilds Early, grown at Giar, were sent to spinners in the United Kingdom for appraisal. It aroused the interest of one firm and there seems no doubt of its usefulness commercially. Agriculturally its merits are high yield, earliness and a high degree of resistance to Abyan root rot of cotton. Routine trials will continue on other possible alternative types and, amongst recent introductions, Ashmouni 34 and Acala 4.42 are being bulked for trial. However, it must be emphasised that Abyan cotton has a good reputation and that a substantial percentage of the crop is bought by firms which are regarded as regular buyers of the Protectorate crop. It is anticipated that, provided quality standards are maintained, there should be no difficulty in

disposing of the crop and, consequently, there is no present intention of replacing L type. Nor is Protectorate output big enough to justify the production of two types. At the same time, information on the performance of other varieties is necessary as a long-term safeguard against significant changes in demand.

Abyan Root Rot

Variation in varietal susceptibility to Abyan root rot of cotton was first noted by Anson. His and later results have shown that, of the types held in the collection at Abyan, Wilds Early has a high degree of resistance to root rot, as has also BAR 12/3 (BP52, B_2), whilst the Lambert and Sakel types are highly susceptible. Anson instituted an attempt to transfer the resistance shown by Wilds Early to the commercial Lambert type. In the absence of any technique for reproducing conditions under which it can be assumed that susceptible plants will succumb to root rot, testing has been carried out by establishing breeding plots on land at Giar farm known to be highly infected with the disease. This method is far from satisfactory, but a high degree of resistance in the hybrid material indicates that it is worth pursuing. Its unsatisfactory nature has, however, been well demonstrated in the last two seasons, when there has been a drop in the percentage mortality of susceptible plants on these fields: in 1959-60 no effective comparison could be made between parent and hybrid material. The possible cause of the decrease in incidence of root rot on these fields is discussed in the Agronomy Section.

Agronomy

BY

K. R. M. ANTHONY AND J. E. A. OGBORN

Crop Rotation

Proposals have been put forward by the section for a system of area rotation of crops. This is determined by expectation of wadi flow, crop water usage, needs of pest control and the desirability of introducing a dry fallow; the basic rotation being cotton—other crops —dry fallow or, in the more fertile area, a four phase rotation with a second crop of cotton following the first. The introduction of a dry fallow is regarded as a preparation for the following cotton crop; the cessation of watering lowering the water-table, allowing weeding and cultivation to take place and building up soil fertility. For reasons of Sudan bollworm control fallow should not follow cotton and land cropped with cotton the previous year should be watered as early as possible. As a pest control measure the sowing period of cotton should be restricted to two months and is thus logically August and September,

the period of most reliable floods. The other crop phase would then utilise water in the period not normally scheduled for cotton.

Under the proposed system the sowing of other crops would take place on land watered from 1st April to 15th July, which had been cropped with cotton in the previous year. From 15th July to 16th September watering would continue on the previous year's cotton land and through to the previous year's dry fallow, all land thus watered being sown with cotton. The small October floods would be used to complete the other crop phase in the Yafai area. On this basis the mean acreages of cotton and other crops, calculated from distribution of available water since 1948, would be almost equal. An average proportion of one-third fallow is adequate to accommodate the annual variation in supply.

Fertiliser Trials

Heavy boll shedding, as a result of *Diparopsis* attack, invalidated the yield data of fertiliser experiments on cotton: early plant height data, which can be considered to be independent of *Diparopsis,* have therefore been used in the assessment of treatment effects.

In a field trial, laid out as a 4 × 4 Latin square, cotton was sown before and after irrigation, with or without sulphate of ammonia at 10 g nitrogen per sq.m applied by placement at sowing. The sowing before irrigation with nitrogen gave very substantially greater plant height (see Table 3). Despite the heavy shedding the yield from this treatment was 790 lb seed cotton per acre, compared with a mean of 85 lb per acre for the three other treatments. This difference, associated with early availability of water, is in conformity with previous seasons' results and demonstrates the importance of time of sowing in relation to watering.

TABLE 3

NITROGEN AND TIME OF SOWING OF COTTON

Plant height (cm) on 24th November

	Sowing time		*Mean*
	Pre-irrigation	*Post-irrigation*	
	±2·1		
No nitrogen	41	39	40
Nitrogen	86	44	65 ±1·5
Mean	64	42	
	±1·5		

(Degrees of freedom for error = 6)

With sorghum also a significant response was obtained with the placement of sulphate of ammonia at sowing, at the same rate, on the Giar rotation experiment (Table 4). There was no interaction with rotation.

TABLE 4

NITROGEN ON SORGHUM: GIAR ROTATION TRIAL

Yield lb per acre

	Grain		*Straw*	
	Yield	%	*Yield*	%
No nitrogen	750	100	4461	100
Nitrogen	1197	160	5883	132
S.E.	±135	±18	±450	±10

(Degrees of freedom for error=12)

As a preliminary evaluation of locally available organic fertilisers a field experiment was laid down comparing: nitrogen at 2 levels, 5 and 10 g nitrogen per sq.m; fish manure and guano, each at 12 cwt per acre; and household refuse at 2 tons per acre. An additional treatment, sulphur, was included, at the rate of 11·4 g per sq.m, as a check on the rôle of nitrogen in the sulphate of ammonia treatment. Sulphate of ammonia, fish manure and guano were applied by placement, refuse and sulphur were broadcast and cultivated in. A randomised block design with four replications was used, there being two control plots per block. Plant height data are summarised in Table 5.

TABLE 5

ORGANIC AND INORGANIC FERTILISERS ON COTTON

Plant height on 24th November

	Mean height cm
Control	89·1
Sulphate of ammonia, single rate	114·5
Sulphate of ammonia, double rate	122·8
Sulphur	104·8
Fish manure	110·0
Guano	128·3
Household refuse	93·3

Standard errors of differences:

between control and a manurial treatment	±11·7
between two manurial treatments	±13·4

Significant and highly significant responses to sulphate of ammonia, at single and double rates respectively, conform with previous experience and it is noteworthy that sulphur alone appeared to have no significant effect. It is hoped to obtain an assessment of the yield response to guano next season, as this fertiliser, available on the offshore islands to the east of Aden, may have practical importance in agricultural development in the coastal areas of eastern Aden Protectorate.

Mechanisation

Ever since the early years of the Abyan scheme the Abyan farmer has been able to use small wheeled tractors for land preparation. A

fortunate decision to standardise on the well tried Ferguson '20' tractor resulted in its widespread adoption, with much less mechanical trouble than might have been expected. To-day a proportion of the privately owned tractors are as well maintained as any in more advanced farming communities. New types of tractors have been successfully introduced and little doubt now exists that the local farmer can successfully operate them. As yet, however, the uses to which these tractors have been put are exceedingly limited. They are almost completely confined to disc ploughing, haulage and pre-sowing cultivation with tines, but this latter is often omitted in favour of repeated disc ploughing. It is evident, therefore, that the versatile potential of the modern wheeled tractor and mounted implements has not been developed.

The research section was not originally intended to carry out investigations on implements, but the need for row-crop cultivations in the areas infested with *Cynodon dactylon* Pers. was immediately evident. A Russell hill-dropper cotton planter was purchased for the 1959-60 season and an experiment was performed with the following contrasts in a factorial design, with four blocks of eight plots.

32 in. versus 16 in. between planting points in rows 36 in. apart.

Timely versus late hand weeding.

Hand thinning to three plants per planting point versus no thinning.

Sowing before versus sowing after irrigation.

The whole experiment was tractor weeded with a rigid tine cultivator.

Unfortunately the 16 in. spacing sown before irrigation was a virtual failure because the seed was covered too deeply by the earth smoothers fitted to the planter. An operational error also prevented a timely resowing of all the pre-irrigation sowings. It was later found that the best results were obtained by removing the smoothers altogether, allowing the seed to be lightly covered by soil falling into the furrow made by the seeder tines. This imitates the seeder action of the local cattle plough drill which normally gives very good germination. Results from this experiment are given in Tables 6, 7 and 8.

TABLE 6

TIME-OF-SOWING AND SPACING OF MACHINE-PLANTED COTTON

	32 in. spacing		*16 in. spacing*	
	Yield seed cotton lb per acre	*Planting points % possible*	*Yield seed cotton lb per acre*	*Planting points % possible*
Sowing pre-irrigation	680	68	377	23
Sowing post-irrigation	974	91	1000	82

Table 7

Thinning and no thinning of machine-planted cotton at two spacings

(*post-irrigation sowing only*)

	32 in. spacing		*16 in. spacing*	
	Yield seed cotton lb per acre	*Plants per planting point*	*Yield seed cotton lb per acre*	*Plants per planting point*
Hand thinned	1058	2·7	917	2·6
Unthinned	892	6·2	1086	4·3

Table 8

Early and delayed handweeding with thinning and no thinning of machine-planted cotton

(post-irrigation sowing only)

Yield of seed cotton in lb per acre

	Early handweeding (started Sept. 21)	*Delayed handweeding (started Oct. 29)*	*Mean*
		±144	
Hand thinned (2·6-2·7 plants per point)	1014	962	988
No thinning (5·2 plants per point)	1228	749	989
Mean	1121	855	
		±101	

The poor stands shown in Table 6 for the pre-irrigation sowings made comparisons involving sowing dates of little value. It is noteworthy that even the 32 in. spacing plots, which were sown at a shallow depth, did not make up for the reduction in planting points by producing a greater yield per plant. Tables 7 and 8, therefore, present results from the post-irrigation sowings only.

It will be seen from Table 7 that neither spacing nor thinning had any great effect on yield. An analysis of covariance confirmed that the number of plants per planting point was quite unimportant under these conditions.

Timely handweeding, however, had a marked effect; Table 8 shows that delayed handweeding in an unthinned crop gave a significant depression of 479 lb of seed cotton per acre.

The experiment demonstrated that the standard cultivating implements already in the area can be successfully used for row-crop cultivation in cotton. Whilst it was not possible to obtain reliable costings from this experiment, the cost of tractor weeding the main crop on the station was of the order of Shs 40 per acre.

The hill-drop type of planter has the disadvantage that it is impossible to cross cultivate the crop and hence the cultivated strip between the plants in the row still needs to be weeded by hand. By cross blocking continuously sown drills it was demonstrated that the normal cattle sown crop could be both thinned and weeded, thus

reducing the amount of hand labour required. It was also shown that by attaching sowing pipes to the rigid-tined cultivator it could be turned into a primitive sowing frame. Seed and, if necessary, fertiliser can be hand-sown in the course of the post-irrigation cultivation by workmen seated on the cultivator. Although this is not the ultimate development of mechanised sowing it represents a considerable advance over present methods and utilises equipment already available in the area.

Mechanisation of the early stages of the crop could result in achieving timeliness as well as ensuring that essential operations do get done. It is noticeable that, when the total Abyan cotton acreage rises much above 20,000 acres, standards of cultivation fall off and invariably some land is left too late to be sown successfully.

Recommended Cultivation Practices

At the start of the scheme various cultural practices were recommended. They were based mainly on a commonsense adaptation of methods used in the Sudan. After watering, the land was to be ploughed repeatedly with disc ploughs and then sown with cattle ploughs or by hand hoe at a spacing of about 3 ft between rows by 9 in. to 12 in. between plants in a row. Early thinning and several weedings were then recommended. The crop was to be removed completely by pulling the plant out by the roots immediately picking was finished.

In practice all operations have tended to be delayed past their optimum period; thorough seedbed preparation is practised by probably a minority of farmers and, above all, crop removal is delayed in many cases until less than a month before water is due to be received for the following crop. There are a number of factors contributing to this situation, of which the one most frequently cited, the disinterest of the average Abyan farmer, is not necessarily the most important. It should also be stated that there are some farmers, normally of some substance, who most energetically carry out the practices recommended and reap their reward in high yields per acre.

It is considered that revised and simplified recommendations, aimed at reducing costs and gaining the acceptance of more farmers, should now be made based on current practices of the research section as set out and briefly discussed below.

1. Plough the land before irrigation, the operation to be done as soon as possible after the removal of the previous crop. The main purpose of the operation is to kill crop residues and weeds by inversion and the use of mouldboard ploughs and one-way ploughing is recommended. Disc ploughing must be accepted for the present, but no new disc ploughs should be imported into the area.

2. After irrigation the land should be cultivated and sown as soon as it can be worked. The land should not be ploughed again. Two passes with the rigid-tined cultivator produce an adequate tilth and the use of sowing pipes on the cultivator enables sowing to be done at the same time. The tines of the cultivator should be arranged to give complete shallow cultivation with one pass. The change in emphasis here is to replace thorough seedbed preparation by a rapid cultivation giving an adequate tilth, the minimum loss of water and the earliest possible germination.
3. The crop should be weeded and thinned within a month of germination. Tractor weeding and thinning supplemented by hand labour is recommended. The crop should continue to be weeded periodically until it is large enough to control the weeds. It should be emphasised that weed control is not particularly difficult under Abyan conditions with the exception of the control of *Cynodon dactylon* in the early stages of the crop in areas with wet soil profiles. The paradoxical result is that thorough weed control tends to be neglected in the drier areas because it is so easy, and apparently not necessary to obtain good crops, and in the wetter areas because it is very difficult by hand labour alone.
4. The crop should be cut out and burned before the date prescribed. This operation, when followed immediately by ploughing gives an adequate clean up of the cotton under Abyan conditions.

Abyan Root Rot of Cotton

Because of evidence of a relationship between soil moisture content and mortality from root rot, fields used for trials on this disease were heavily watered in an attempt to increase its incidence. In fact, plant mortality on the heavily watered area proved negligible and thus it was not possible to assess the resistance of hybrid material nor the effects of a range of soil sterilisers under investigation. Light is thrown upon the cause by results of a field trial investigating the influence of water duty and the possibilities of chemical control. In this trial a comparison was made of two rates of watering, 15 cm and 100 cm, and four rates of Shell D-D, 0, 16, 32 and 64 ml per sq.m, in two blocks of eight plots. Plots were split for two varieties: resistant Wilds Early and susceptible Lambert type. Summarised data for plant mortality are given in Table 9.

The difference in total plant mortality of 74 ± 24 (with six degrees of freedom) indicates a significant reduction in root rot with the higher application of water, but this was associated with poorer early growth, an indication of nitrogen deficiency and reduced yield. The

yields with the higher rate of watering were 34 and 50 per cent. lower for the Lambert and Wilds Early varieties respectively in spite of the lower wilt incidence.

TABLE 9

TOTAL PLANT MORTALITY FROM ROOT ROT

Number of Plants

Water rate	*D-D rate*				*Total*	*Total per cent of initial population*
	—	*1*	*2*	*3*		
15 cm	15	36	28	12	91	20
100 cm	3	0	3	11	17	4

The explanation may rest in differences between the distribution of the early rooting system under the two watering régimes and it is possible that under heavy watering a shallow early rooting system was formed with plants less liable to root rot. If this is correct then varietal susceptibility may be linked with the pattern of early root distribution.

Other Crops

A further series of fertiliser trials on wheat and sorghum were carried out in the Wadi Hadhramaut, in co-operation with the Agricultural Officer, who also initiated extension work by establishing demonstration plots in the western section of the wadi. Trials over the last four years have yielded valuable information and provide a basis for recommendations on fertiliser practice. A note on this work will be prepared for separate publication.

A preliminary trial on cultivation practices and nutrient requirements of wheat was carried out in the Beihan Emirate, in co-operation with the Agricultural Officer, Beihan.

Trials with groundnuts have established that the crop can be satisfactorily grown in the coastal area under conditions of flood irrigation. In 1959, yields with the Sudan bunch type KCA ranged from 1,000 lb per acre unshelled nuts on poor land at Giar to the equivalent of 3,500 lb unshelled nuts per acre from a half acre field at Kod farm. The crop is new to the Aden Protectorate.

SOIL SCIENCE

BY

J. E. A. OGBORN

Variations in Water Supply Affecting Crop Rotation

Daily records of river flow of the Wadi Bana have been kept by the Abyan Board since May 1948 and constitute a most valuable record of the variations characteristic of this type of wadi. Monthly averages of total flow in millions of cubic metres derived from these records are summarised below (Table 10).

TABLE 10

RIVER FLOW OF THE WADI BANA

Millions of cubic metres

Month	*April*	*May*	*June*	*July*	*August*	*September*	*October*	*November*	*December*	*January*	*February*	*March*
No. of years records	12	13	13	13	12	12	12	12	12	12	12	12
Average flow	16·0	15·3	5·7	25·5	57·2	25·6	5·5	2·8	3·5	2·6	1·5	6·4
Median flow	11·6	8·3	3·4	17·9	52·2	22·4	4·0	2·3	2·3	1·4	1·5	4·5
C.V. %	93	154	93	70	56	62	115	83	86	160	88	98

TABLE 11

WEEKLY RIVER FLOW JULY 1-SEPTEMBER 30 (1951-59)

Millions of cubic metres

Week	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Mean value	2·8	3·4	6·4	7·9	15·2	12·3	14·2	14·3	14·0	8·7	6·4	8·7	2·9
Median value	1·3	2·2	5·5	5·2	13·6	12·3	10·1	11·6	10·7	7·8	7·9	3·0	1·5

It can be seen that the two distinct flood periods of seif (April and May) and kharif (July, August, September) contain over 83 per cent. of the average flow, whilst the months of July, August and September have the highest average flows and lowest coefficients of variation (C.V.). The latter period should therefore logically be used to sow the main cash crop.

To ensure control of *Dysdercus* it is necessary to restrict cotton sowings to a total period of nine weeks or less and it is therefore necessary to consider the weekly totals in order to select the best consecutive period of nine weeks. Table 11 gives the mean median values for the thirteen weeks between 1st July and 30th September inclusive, derived from the years 1951-59.

It can be observed that, except for week 12, the mean weekly values increase and decrease in an ordered manner about a centre of highest expectation in weeks 7, 8, 9, i.e. 13th August-2nd September. As is indicated by median value, the high value for week 12 is due to a single large flood received in 1955 for which the statistical expectation must be very low indeed. The values for the possible nine-week periods are shown in Table 12.

TABLE 12

MEAN RIVER FLOW FOR POSSIBLE COTTON SOWING PERIODS

Millions of cubic metres

Weeks	(1-9)	(2-10)	(3-11)	(4-12)	(5-13)
Mean	90·5	96·4	99·4	101·8	96·8
C.V.%	42	40	41	38	38

There is little to choose between the means of the periods and their measured variation over a period of nine years. The long term mean of period (4-12) is almost certainly the same as or smaller than that of period (3-11) owing to the anomalous value for week 12.

A detailed examination of past records has been performed to assess potential losses to the sea from a planned construction of an additional spillway in the Wadi Bana. No reliable estimate can be made of average losses from the present irrigation system. However, while the present system continues to use earth diversion dams, it is obvious that on average more water will be lost to the sea from a later period than from an earlier period. The period (3-11), i.e. 15th July to 16th September, is therefore recommended for cotton irrigation at present.

The potential losses from an improved irrigation system would reduce the mean available flow for the period (3-11) during 1951-59 to a minimum of 88·8 with a coefficient of variation of 40 per cent. For the period 1948-60 inclusive, the mean available flow is estimated to have been 80·7 with a coefficient of variation of 44 per cent. The value for the mean available flow for the months of July, August and September for the same period of years was 98·5. The restriction of the cotton irrigation period to nine weeks would therefore have reduced the

potential acreage by 18 per cent. This loss of acreage must be balanced against the increased yields and the improved grade which may be expected in a crop free from bollworm damage. The mean minimum total available supply throughout the rest of the year is estimated to be 74·4, but it is probable that losses to the sea from the occasional very large floods received in April and May would in fact be less than theoretical because of the moderating effect of the dry wadi bed at this time of year.

The variation in annual cotton irrigation supply alone makes it necessary to have available an irrigable area equivalent to nearly twice the annual mean. This implies that in most years there must be a proportion of the area in dry fallow. The volume of water received outside the maximum allowable cotton irrigation period is almost half the total. Used efficiently this could produce an average acreage of other crops nearly equal to the maximum possible acreage of cotton.

It is demonstrated in the Entomological Section of this report that the previous year's cotton land should be watered during the period April to September if possible. Table 13 shows the extent to which this is possible.

Table 13

Relationship between April-September supply and previous year's cotton supply

Season	*Previous cotton supply millions of cu.m*	*April-September supply millions of cu.m*
1949-50	57·2	79·4
1950-51	55·2	148·6
1951-52	56·4	181·7
1952-53	147·7	96·9
1953-54	86·9	156·9
1954-55	65·9	208·3
1955-56	145·4	97·8
1956-57	64·1	100·5
1957-58	67·0	157·3
1958-59	81·2	61·1
1959-60	48·0	121·3

In eight of eleven years the April to September supply exceeded the previous season's cotton supply. If, therefore, all water supplies were used with equal efficiency a high degree of entomological control could have been achieved. Unfortunately, owing to a number of reasons, both administrative and technical, the smaller flows of the seif flood are at present used much less efficiently than those of the kharif flood.

This examination demonstrates that if effective irrigation control and distribution becomes technically possible through the completion of major irrigation works and the lining of canals it will be possible to adopt a practicable scheme of progressive watering and cropping in spite of the marked seasonal variations in supply.

It is noteworthy that the highest April to September supply was only 134 per cent. of the potential available annual mean, of which a

proportion would be used for short term crops other than cotton. A total area equivalent to 150 per cent. of the annual mean would therefore be adequate to absorb the variation in supply.

We are indebted to the Chief Engineer Abyan Board for permission to quote the hydrological data on which this section is based.

Irrigation Experiment 1959-60

A thirty-two plot experiment was laid out at both Giar and El Kod farms. That at El Kod was on land after an involuntary one-year dry fallow, while the Giar experiment was on the site of the 1958-59 irrigation experiment. At the time the programme was planned, the accuracy of gravimetric estimates of stored water by means of a single auger-boring per plot seemed to be insufficient to make valid estimates of changes under a crop. All observations at Giar were therefore concentrated on the one block of the experiment which contained Farbrother nylon units. The result of the Kod experiment showed that the gravimetric technique used was most effective and the loss of information at Giar as a result of this mistaken decision is much to be regretted.

The design incorporated factorial applications of nitrogen, phosphate and potash manures, endrin spray treatment and a watering contrast of 30 cm vs. 15 cm total irrigation. Unfortunately an accidental watering of unknown size was given to the Giar experiment and, in the event, the contrast was between plots receiving rather less than 15 cm accidentally applied and the same amount plus a measured 15 cm. The evidence from soil sampling and resistance readings indicated that the maximum application was about 27 cm and that the accidental application varied from 5 cm to 12 cm.

This experiment suffered also from an abnormally heavy attack of *Diparopsis* which so damaged the unsprayed plots that they contributed no information of value concerning the other factors under trial. The plots protected by endrin spraying however gave a clear difference in yield between the two rates of irrigation; those receiving the higher rate averaged 1,309 lb seed cotton per acre and those with the lower rate 613 lb.

The experiment at El Kod gave very vigorous even growth and heavy yields; damage by bollworms was comparatively light but gave rise to some interesting effects. The formal analysis of yields at El Kod showed that not only did endrin significantly increase yields by 404 lb per acre in an experiment with a mean yield of 3,870 lb of seed cotton per acre, but it also gave significant interactions with nitrogen and phosphate. These are set out in Table 14. An interesting interaction between nitrogen and added irrigation was also observed (Table 15).

Table 14

Irrigation experiment at El Kod—endrin spray in combination with three other factors

Yield of seed cotton in lb per acre

	Irrigation water		*Nitrogen*		*Phosphate*		*Mean*
	15 cm	*30 cm*	—	*N*	—	*P*	
No spraying	3728	3608	3849	3487	3839	3496	3667
Sprayed	4210	3932	3856	4285	3839	4303	4071
Increase with spraying	482	324	7	798	0	807	404
S.E. of this increase			±199				±143

Table 15

Irrigation experiment at El Kod—nitrogen at two levels of irrigation

Yield of seed cotton in lb per acre

	Irrigation		*Mean*
	15 cm	*30 cm*	
No nitrogen	4118	3589	3854
Nitrogen	3821	3951	3886
Difference	−297	+362	+32
S.E. of this difference	±199		±143

It had been intended to install resistance units in all the El Kod plots before irrigation but difficulties of supply prevented this and it has been necessary to rely on gravimetric determination of moisture changes. It was only practicable to perform three sets of borings: once before irrigation; once after the crop had been completed; and once at intermediate dates to install resistance units as they were received. The dates varied from 24th September for block I to 15th November for blocks III and IV.

The initial sampling to 175 cm showed an average stored water content of 45·6 cm and 46·5 cm for the 30 cm and 15 cm plots, respectively, before irrigation. This stored water was assessed on an oven-dry basis. The sum of stored water and the irrigation applied was defined as nominal available water, in this case 75·6 and 61·5 cm on average respectively. By subtracting the stored water remaining in the profile at the end of the crop it is possible to assess the gross water consumption during the growing season. This is shown in Table 16.

Table 16

Cotton water consumption: El Kod irrigation experiment

(*Cm*)

Irrigation treatment	*Initial stored water*	*Irrigation*	*Intermediate stored water*	*Final stored water*	*Consumption*
30 cm	45·6	30	46·8	20·9	54·7
15 cm	46·5	15	46·5	21·1	40·4

Yields: 15 cm irrigation 3969 lb per acre
30 cm irrigation 3770 lb per acre

The 30 cm irrigated crop consumed 15 cm more water and produced 200 lb less seed cotton per acre. This result was certainly unexpected and the detailed examination of the effects of the various factors on water consumption will not be completed in time for inclusion in this report. A preliminary examination does, however, reveal several interesting features.

TABLE 17

EARLY AND LATE WATER CONSUMPTION OF COTTON

(*Cm*)

Irrigation treatment	*Early consumption*	*Late consumption*
30 cm	28·8	25·9
15 cm	15·0	25·4

Table 17, computed from Table 16, shows the consumption split approximately into the periods before and after the formation of full leaf cover and demonstrates that the later consumptions were approximately equal.

The height assessments made on 5th November showed that the 30 cm plants were 6·9 cm taller in a crop with an average height of 46·7 cm. This difference was statistically significant at a level of 1,000 to 1. There was a positive interaction with nitrogen giving a significant height increase of 3·3 cm. The estimated leaf area indexes at this stage of the crop were 0·82 and 0·45 and the equivalent leaf densities 3·4 and 4·4 mg per cm for the 30 cm and 15 cm treatments respectively. This evidence shows that, in the early stages of the crop, the more lightly irrigated plots might have been expected to transpire less water. This is confirmed by the details of Table 18.

TABLE 18

STORED WATER IN THE PROFILE UNDER COTTON

(*Cm*)

	Initial stored water		*Intermediate stored water*		*Final stored water*	
Irrigation treatment	*30 cm*	*15 cm*	*30 cm*	*15 cm*	*30 cm*	*15 cm*
Soil layer						
0- 25 cm	9·5	10·9	6·4	6·0	2·6	2·8
25- 75 ,,	13·2	15·9	11·9	12·5	5·3	5·7
75-125 ,,	15·6	12·2	13·2	14·3	6·7	6·7
125-175 ,,	7·3	7·5	15·3	13·7	6·3	5·9
Total	45·6	46·5	46·8	46·5	20·9	21·1

The soil layer 75-125 increased in moisture content on the 15 cm plots and decreased on the 30 cm plots. It is not possible to calculate the drainage losses from below the sampled profile, but the first reliable resistance readings at a depth of 175 cm from block I on 22nd September gave average readings of 4·1 and 4·2 log. ohms for the 30 cm and 15 cm plots. These readings indicate moisture contents well

below field capacity and indicate that drainage would certainly be slow.

The situation, therefore, was that at the time of the intermediate sampling a population of larger plants adapted to a lower moisture stress on the 30 cm plots had stored water reserves in the sampled profile which were only equal to those of the 15 cm plots. Under conditions where moisture was limiting it appears probable that the 30 cm plots ran short of water and were unable to develop their full potential crop. Table 19 illustrates the seed cotton production before and after the peak rate of production which was obtained at the pick made on 17th March.

Table 19

Total production: El Kod irrigation experiment

Seed cotton lb per acre

Treatment	*Up to 17th March*	*17th March to 20th April*
15 cm	2368	1601
30 cm	2496	1273

Confirmation of the increased water strain in the 30 cm plots during the late stages of the crop is demonstrated by the significant relative turgidity differences shown in Table 20.

Table 20

Relative turgidity %

Treatment	*At 11th November*	*At 9th March*
15 cm	83	69
30 cm	89	63
S.E. (12 D.F.)	±2·29	±2·25

Mean maximum visible rooting depths were determined by borings at the end of the crop. There was no significant difference between treatments, and the mean depth of 118 cm is primarily of interest in indicating the approximate centre of uptake at the end of the crop. The deepest recorded depth was 211 cm on a 30 cm plot and there seems little doubt that plants of this size frequently put roots down to those depths. The smaller plants on the Giar experiment, whilst having almost the same mean rooting depth (117 cm), had only one plant which exceeded 190 cm.

The yields on the El Kod experiment were so far outside the normal range of commercial crops that information derived from it may be misleading, but they are of interest as indicating possible yields under ideal conditions. The plots receiving 15 cm yielded more cotton, both absolutely and relatively, with regard to the water consumed. It is probable that most of the deep water-table areas of Abyan with adequate storage capacity would yield similar results after a dry fallow.

The experiment also showed that only under the highest fertility levels will the cotton crop grow big enough to consume more than 30 cm under Abyan conditions, and that cotton should ideally be sown on lightly watered land out of a dry fallow which contains some stored water residues. The rotation proposed in an earlier section of this report (page 6) is designed to ensure this.

Water-table Movements 1959-60

In spite of the larger volume of water entering the area during the 1959 kharif it is very gratifying to be able to record no marked rise in the water-table. Table 21 demonstrates the water-table movement as recorded in open wells, 1959-60. Comparable readings for 1958 are included for reference.

TABLE 21

WATER LEVELS IN OPEN WELLS, 1958-60

Metres below soil surface

	Period		
Well group	*May 1958*	*May 1959*	*May 1960*
Giar	6·65	6·83	7·17
Dirgag marsh	2·44	3·25	2·92
Hassan east	13·25	16·00	13·30
Rumeila marsh	3·26	3·24	3·70
Makhazan	6·01	6·85	7·25
Means (weighted)	5·66	6·32	6·26

The movement of the water-table at Giar farm during 1959-60 conformed to the general water-table movements but there was a marked rise of 57 cm still to be observed in May 1960 below the fields which were deliberately overwatered during August 1959.

Owing to the destruction of the grid of observation tubes water-table levels were recorded for a larger number of wells than in previous years.

The water-table situation in the areas which receive most regular watering is illustrated by Table 22.

TABLE 22

DISTRIBUTION OF WATER-TABLE DEPTHS

Number of wells

Water-table depth in metres	*Central area*	*Remainder*	*Salinity rating*
0- 4	4	0	Salt marsh
4- 8	16	10	Salty patches
8-12	2	5	No salinity
12-16	0	9	No salinity
16-20	0	2	No salinity
Total	22	26	
Mean depth	5·9 m	10·6 m	

It will be observed that in the Central area, which is defined as the area between the two wadis north of the line Giar-Ober Othman, only four of twenty-two wells have water levels in the range 0-4 m. This represents the approximate proportion of the area which is threatened by serious salinity troubles.

Outside the area, no dangerous levels were recorded, though some reduction in yields might be expected from the water-levels in the range 4-8 m.

Entomology

BY

J. H. PROCTOR

Incidence and Biology of Cotton Insects

Diparopsis watersi (Roths.) first appeared in the commercial crop on the first formed buds of *punctatum* hybrids. Its incidence in Abyan differed markedly between those northern areas which had been cropped with cotton the previous season, represented by the Research farm at Giar, and the southern areas, including El Kod, which had lain fallow the previous year due to the failure of the floods to reach them.

The clean up of the previous crop over much of the northern part of Abyan was delayed, and in the Dirgag area, particularly, considerable shedding was caused by *Diparopsis*. Regular boll collections made at Giar revealed the proportion of damaged bolls to reach fourteen per cent. by the end of January, while over eighty per cent. of shed buds and over sixty per cent. of shed bolls recovered from December onwards were damaged by *Diparopsis*. Damage at Giar, however, was greater than elsewhere in the district as a result of interception of the main moth flight by early sown cotton, part of the investigations on moth flight described below. In the remainder of the northern area, excluding Dirgag, the incidence of *Diparopsis* was much as in previous years.

In the southern areas, which had had an enforced dry fallow the previous year, bollworm damage was less than usual. The percentage of damaged bolls at El Kod remained very low until the end of March, and during the main period of bud shedding in December and January the proportion of shed buds recovered damaged by *Diparopsis* did not exceed forty per cent. The proportion of shed bolls damaged did not exceed twenty per cent. until the end of March.

The incidence of *Diparopsis,* therefore, changes with annual variations in the availability of water resulting in fluctuations in the area watered. When land cropped with cotton the previous season is

left unwatered, moths emerging in November to January are intercepted by cotton on neighbouring land in a suitable stage for breeding. Cotton surrounded by or fringing unwatered land is therefore heavily attacked at a critical stage of crop formation and heavy losses can result. Conversely, when a year of poor floods is followed by one of good water supply a large area of cotton is available to absorb any small moth flight emerging from long cycle pupae eighteen months old and the crop occupying land unwatered the previous year is very lightly attacked.

Investigations into the diapause mechanism were limited by the small number of larvae set to pupate in the previous season, only 66, of which only 25 emerged. Of these only one was long cycle, emerging after a diapause of ten months. The cages in which the larvae pupated were not watered, as were those of previous years, thereby simulating the effect of the dry fallowing of cotton land. The emergence of the one surviving long cycle pupa in December supports the evidence of the previous season, when the land around El Kod was fallowed, that emergence from unwatered cotton land occurs from November to January. The pupation cages of the previous year were retained and watered in September to investigate the possibility of long cycle pupae remaining in diapause until the subsequent season but one, and one emergence was recorded after a diapause of twenty months. In the present season 695 larvae have been set to pupate. Emergence ceased in April, when the mean temperature of the soil at three inches reached 35° C. A small emergence followed a drop in soil temperatures caused by 66·8 mm of rain on 20th May.

The results of pupation trials indicate that emergence from long cycle pupae formed the previous season occurs mainly over the two months or so following watering. The occurrence of the moth flight was investigated at Giar by making bi-weekly egg counts on cotton sown by tube well at the beginning of July. Counts remained low until the middle of September, a month after the watering of the farm, when over ten eggs per plant were recorded at each count. The *Diparopsis* larvae stripped the plants completely of their young fruiting points and caused considerable damage by boring into the growing points. The weight of this attack confirms the occurrence of the moth flight over the period following watering, and the subsequent heavy infestation of surrounding cotton amply bore out that the most important means of carry-over of *Diparopsis* is the interception of the moth flight by cotton sown too early or by cotton left unpulled from the previous crop, which rapidly comes into bud on watering.

Bi-weekly egg counts were also made on a small number of unpulled plants from one of the previous experiments at El Kod. As growth and budding continued slowly over the summer a few eggs

were recorded from May onwards, but there was an increase in egg laying during October, within a month of watering the surrounding land. As this had lain fallow the previous year, this increase in moth activity is taken to indicate an emergence of long cycle pupae on watering after a diapause of eighteen months.

The relation of moth flight to the cotton crop is undoubtedly the most important natural agency controlling *Diparopsis*. Parasitism is negligible, only one species, *Drino* (*Prosturmia*) *inconspicua* Mg. having been found, causing only a low degree of parasitism and apparently only in the first stages of the crop.

The larger part of the moth flight occurring after watering is spent before cotton is suitable for breeding unless it is intercepted by cotton sown on very early floods or by unpulled cotton of the previous year. General recommendations for the control of *Diparopsis* are therefore that a strict close season be enforced and that sowing of cotton be restricted to August and September. This eliminates the possibility of interception of the moth flight unless there is a late emergence of moths from November to January from unwatered land cropped with cotton the previous year. Water resources permitting, it is important to secure the early watering of land cropped with cotton the previous year, and a dry fallow should never follow cotton in any rotation that may be introduced.

Heliothis armigera Hb. occurred in December and January in small foci in the southern area. It caused complete shedding of the first formed buds, and after stripping the plants the larvae bored into the monopodium through the young axillary buds. Numbers declined in late January, and the pest was very rare in the later stages of the crop. The plants recovered, and there was little or no loss of crop although some delay. At El Kod *Heliothis* appeared first on *Dolichos* and groundnuts, thence moving into cotton and persisting last on pigeon pea. Other hosts include *Hibiscus esculentus,* maize and tomato. The absence of *Heliothis* over the summer on the few hosts available in gardens suggests that long cycle pupae are formed. On groundnut, *Dolichos* and cotton, *Heliothis* was heavily parasitised by the tachinid *Goniophthalmus simonyi* Vill.

Earias insulana Boisd. was of no more importance than in previous years, and *Platyedra gossypiella* Saund. was not found except in samples of cotton from the high water table area of Meifa Hajr in the East Aden Protectorate, where it has occurred regularly since cotton was introduced.

Aphis gossypii Glov. occurred in patches in well-grown cotton with a dense leaf canopy in the southern areas of Abyan. Important predators include *Cheilomenes propinqua* Muls., *Xanthogramma aegyptium* Weid. and Chrysopidae.

Empoasca libyca de Berg. and *E. flavescens* (Fabr.) occurred, but caused serious leaf symptoms only in very poorly grown cotton and in well-grown cotton too widely spaced and with incomplete ground cover. Leaf symptoms were particularly marked in areas of Lahej, where spacing was excessively wide, and in an experiment at El Kod where the removal of the buffers simulated excessive spacing. The main alternate host is *Solanum dubium* which, in the absence of effective rainfall, appears after irrigation of the cotton land and does not dry out until the cotton is well grown. There is, therefore, no mass migration of jassids from this host to young cotton at a critical stage of growth, and high jassid populations are therefore seen only in well-grown cotton in January and February.

Minor pests included *Bemisia tabaci* Genn., *Podagrica puncticollis* Wse. (which appears to prefer *Abutilon muticum* to cotton), *Sphenoptera gossypii* Cotes, *Oxycarenus hyalinipennis* Costa, *Creontiades pallidus* (Ramb.), *Laphygma exigua* (Hb.), *Prodenia litura* (F.) and *Xanthodes graellsii* (Feisth.).

Spraying Experiments

Three insecticide experiments were laid down against *Diparopsis,* using endrin 0·1 per cent. emulsion sprayed to runoff. Two at Giar were performed under conditions of heavy bollworm attack, the third at El Kod representing conditions of light infestation. Two were factorial experiments carried out in co-operation with the soil scientist, the third a non-factorial experiment involving insecticide only.

Irrigation experiment, Giar.—Spraying with endrin emulsion weekly from the first buds was one of the factors in this experiment, mentioned on page 17. *Diparopsis* attack was extremely severe, owing mainly to the interception of the moth flight by the early sown cotton, mentioned on page 23. The sprayed plants were virtually free of bollworm throughout but the unsprayed suffered extremely heavy damage and gave an average yield of only 61 lb of seed cotton per acre against 961 lb from the sprayed plots. With a yield difference such as this an overall statistical analysis of conventional form would not be valid, and is of course unnecessary to show the reality of the effect of endrin. The spraying reduced the proportion of stained lint from 9 per cent. to 1 per cent.

The tremendous reduction in yield was associated with very heavy shedding and consequent very tall straggly growth. Node counts at the close of the experiment showed 88 per cent. shedding on unsprayed plants and 39 per cent. on sprayed. Sprayed plants averaged 65 cm in height against 106 cm unsprayed.

Irrigation experiment, El Kod.—This experiment also has been mentioned earlier and the yields presented in Table 14. Endrin spraying gave an increase, over the already very high yields of the

unsprayed plots, of 404 lb per acre in spite of the low incidence of *Diparopsis* following an enforced dry fallowing in the previous year.

Two important species occurred besides *Diparopsis*. In December there was an attack of *Heliothis,* and from January onwards *Aphis* occurred. The endrin was effective against both. In December node counts indicated that endrin reduced shedding from 20·4 per cent. to 10·2 per cent., the effect, which was highly significant, being due to the control of *Heliothis* on the sprayed plots. The endrin reduced *Aphis* infestation in March from 31·7 per leaf to 4·2 per leaf, a very highly significant reduction.

The total percentage shedding at the end of the experiment as determined by node counts was reduced by the endrin from 58 per cent. to 45 per cent. This also was statistically a very highly significant reduction but it is noteworthy that the early loss of fruiting points by *Heliothis* attack was compensated for by late growth, and the combined effect on yield of the early *Heliothis* attack, the subsequent *Diparopsis* infestation and the leaf infestation of *Aphis* was proportionately small.

The unsprayed plots, however, cropped later than the sprayed. The larger part of the delay was most probably due to stripping by *Heliothis* of the first-formed fruiting points. Thus while only 7·6 per cent. of the crop of the sprayed plots was picked in April, 17·5 per cent of that of the unsprayed plots was picked in April. Early loss of fruiting points was thus compensated for to a large extent during a long growing season.

Cotton spraying experiment, Giar.—To determine the period of crop development over which insecticidal protection is most effective against *Diparopsis,* four different treatments were applied to cotton at Giar in a randomised block design with six replications. Plot size was 4 metres × 4 metres with 2 metre buffers.

The treatments were:

A. Sprayed 0·1 per cent. endrin weekly to runoff from first buds to end March.
B. Sprayed similarly from first buds to mid January.
C. Sprayed similarly from mid January to end March.
D. Not sprayed.

Weekly plant diagrams were made on two plants in each plot to investigate the pattern of shedding. To summarise the shedding data, by the middle of January endrin had reduced the percentage bud shedding from 36 to 16 per cent. (significant at 0·1 per cent.). Thereafter a clear difference remained in percentage shedding between treatments A and D, but there was neither a considerable increase in shedding in B nor a considerable reduction in C. The crop set in B

during the period of endrin protection largely matured when insecticide applications ceased, while during the period of endrin protection from mid January onwards C was unable to replace the fruiting points previously lost. Indeed the final yield from C was less than that from D, which was unsprayed throughout (Table 23).

TABLE 23

COTTON SPRAYING EXPERIMENT, GIAR

Yield of seed cotton

	Period of spraying			*Unsprayed control*	*S.E.*
	A	*B*	*C*		
Lb per acre	1133	782	535	558	±119·1
% control	203	140	96	100	± 21·3

Growth on this experiment was poor and the crop had closed down before the end of March. Whereas the well-grown cotton on the irrigation experiment at El Kod could withstand any early loss of fruiting points and, in the absence of heavy subsequent *Diparopsis* attack, replace them to produce a later crop, the poorer cotton at Giar with a shorter effective growing period could not replace from mid January onwards the fruiting points already lost. The Giar experiment indicates the importance, in the chemical control of *Diparopsis,* of protection during the early rather than the later stages of the crop when the length of the growing period is limited.

Empoasca and Aphis

A non-replicated trial of Rogor 40 against *Empoasca* spp. was performed on a 7 × 8 lattice experiment laid down to compare 56 progenies. Serious hopper burn followed the removal of buffers, and Rogor 40 was applied to the two replicates X and Y on 27th January at 8·6 fluid ounces per acre in 100 gallons of water per acre. Replicate Z was left unsprayed. Jassid counts per 80 leaves on successive occasions on the three replicates gave the following results (Table 24).

TABLE 24

Nymphs per 80 leaves

	Jan. 26	*Jan. 28*	*Jan. 30*	*Feb. 7*	*Feb. 18*
X	381	84	39	30	13
Y	393	92	71	31	8
Z	333	327	379	137	39

There was later an increase in *Aphis,* and on 10th March Rogor was applied to X and Y at 21·3 fluid ounces per acre in 100 gallons of water per acre. Counts of *Aphis* on 80 leaves before and after application are shown in Table 25.

TABLE 25

Aphis per 80 leaves

	Feb. 13	*Feb. 23*	*Mar. 9*	*Mar. 12*	*Mar. 17*	*Mar. 23*	*Apr. 2*	*Apr. 13*
X	260	402	1919	0	0	4	1	5
Y	239	296	1634	0	0	5	0	0
Z	790	Innumerable						

Although there was no replication the yields in lb seed cotton per acre finally obtained are of interest. They were X, 3,547; Y, 3,751; Z, 2,695.

The drop in yield of Z (some 800 lb per acre) may well largely represent the effect of a heavy *Aphis* infestation on well-grown, high-yielding cotton. It is noteworthy that Z closed down before X and Y.

PUBLICATION

Lord, E. and Anthony, K. R. M. (1960).—Effect of exposure to the Aden climate on cotton lint strength. *E.C.G. Review,* **37**, 10-14.

APPENDIX

KEY TO SYMBOLS USED IN THE REPORT

AB Control	Rogued material from Sudan Lambert X1730A.
AB1	Bulked selections fromX1730A.
BAR XL1	An importation from the Sudan. First filter of BAR 1730L.
K1	First bulk filter of BAR XL1.
Domains Sakel	An importation from the Sudan.
Ashmouni 34	A high quality selection from Egyptian Ashmouni.
Wilds Early Acala 4.42	American long staple types.
BAR 12/3	Uganda BP52 carrying B_2.

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PROGRESS REPORTS FROM EXPERIMENT STATIONS

The reports for the seasons up to and including 1950-51 were published in seasonal volumes; the following are still in print and available at 3/- per volume post free.

1923-25 (one volume), 1926-27, 1931-32, 1934-35,
1935-36, 1942-43 and 1945-46 to 1950-51.

From 1951-52 the reports from each territory were published individually each season. A few of the 1951-52 reports are out of print, but all others are available post free at 2/6 per report or £1 for the seasonal set.

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